

Chapter 8: Supplemental Technologies for Treating Stormwater Discharges into the Everglades Protection Area

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Summary

Phase II of the Everglades Program is focused on identifying, demonstrating and implementing stormwater treatment technologies to achieve State standards. Because the phosphorus (P) removal goals of the Act may be lower than the stormwater treatment areas (STAs) can achieve alone, the District, in conjunction with Florida Department of Environmental Protection (DEP) and the Everglades Protection District, is developing and evaluating alternative treatment strategies for reducing P concentrations to meet a planning goal of 10 ppb for total phosphorus (TP). Supplemental technologies, as they were originally described in the Act, are envisioned to work with or in place of STAs to meet the final P target. However, the best combination of treatment technologies to meet the P concentration goal may include enhanced Best Management Practices (BMPs), as well as STAs and supplemental technologies.

All candidate treatment technologies are being evaluated against the same criteria: load reductions; discharge concentration reductions; water quantity, distribution, and timing for the Everglades Protection Area (EPA); compliance with water quality standards; compatibility of treated water with the balance in natural populations of aquatic flora or fauna in the EPA; cost-effectiveness; and schedule for implementation. Other evaluation criteria may include, but not be limited to, technical feasibility, possible adverse environmental impacts, local acceptability, and marsh readiness of the effluent. All supplemental technologies must be applicable at the basin scale, i.e. they must be able to treat the runoff generated within an Everglades Agricultural Area (EAA) basin during storm events. Work that is currently under way will result in information on P removal performance, estimated costs, and compatibility with Everglades flora or fauna for all of the candidate supplemental technologies.

Over two dozen-water quality treatment technologies were screened in the Desktop Evaluation conducted for the District by Peer Consultants/Brown and Caldwell in 1996. The District originally proposed to investigate five of the most promising technologies (wetlands, managed wetlands, chemical addition/direct filtration, low intensity chemical dosing, and submerged aquatic vegetation (SAV)/limerock). However, special condition #7 of the United States Army Corps of Engineers (USACE) Section 404 permit for construction of the STAs in Phase I lists nine technologies to be investigated. In addition to the five technologies listed above, the Section 404 permit requires the District to conduct research on chemical addition/dissolved air-flotation, chemical addition/high-rate settling, microfiltration, and periphyton-based stormwater treatment areas (PSTAs).

Research on these technologies began in 1997 with the microfiltration (conducted by DEP), low intensity chemical dosing (conducted by the Everglades Protection District) and combined chemical treatment/solids separation studies. In 1998 the District, through its contractors, began work on the SAV/limerock and PSTA research programs, with work scheduled to begin on managed wetlands by the end of 1998. All research will be completed by December 31, 2001, as required by the Act. It is clear from this

schedule that information on the most promising supplemental technologies will not be available in time to be incorporated into the design of STA-3/4 (scheduled for 1999 through 2000). It is also clear that the deadline for the water quality strategy required by the USACE Section 404 permit (January 1, 2001) may be difficult, if not impossible, to meet.

Information on the potential implementation costs for Phase II is not currently available. Preliminary cost estimates and benefits for some of these technologies were developed in a desktop evaluation conducted in 1996 (Peer Consultants P.C./Brown and Caldwell). However, the assumptions used to develop these cost estimates have, in many cases, proved incorrect. Based on the results of the microfiltration project and early results from the chemical treatment project, the costs to implement these particular alternative treatment technologies are much higher than those projected in 1996.

District staff will be evaluating the performance results from BMPs and STAs, as well as the results of the research and demonstration projects for supplemental technologies and STA optimization, as the information becomes available. This information will be used to begin the selection of the most promising combination of technologies to meet the final P standard, and will be included in the water quality plan required by the Act by December 31, 2003 (See **Chapter 12**). The ultimate combination of approaches will also need to consider the site-specific conditions that will potentially affect the successful implementation and performance of the combined treatment technologies.

The Act Requirements for Supplemental Technologies

The Everglades Forever Act (Act) of 1994 mandates that the DEP and the District design and carry out the Everglades Program, a series of fifty-six (56) projects including research, regulation, and construction activities to restore the Everglades (See **Chapter 1**; SFWMD and DEP, 1997). The Everglades Program is designed to achieve interim ecosystem restoration goals and to identify and subsequently achieve long-term water quality and management goals.

The Act directs the District and the DEP to initiate research and monitoring to generate sufficient water quality data and to evaluate the effectiveness of Stormwater Treatment Areas (STAs) and Best Management Practices (BMPs) in improving water quality. The DEP is directed to initiate rulemaking to establish a numerical Florida Class III Water Quality Standard for P entering the Everglades Protection Area (EPA) by December 31, 2001. If rulemaking is not completed and a P standard is not established by DEP by December 31, 2003, the Act establishes a default P criterion of 10 parts per billion (ppb). Other responsibilities established by the Act require DEP to establish a relationship between discharge levels and water quality in the EPA, and the District and DEP to use this relationship to set a discharge limit for the STAs and other discharges into the EPA. In addition, the Act specifies that constructed wetland treatment systems, coupled with the use of on-farm best management practices to reduce P loading at the source, currently are the best available strategies for achieving interim water quality and hydropattern restoration goals.

Because the P removal goals of the Act may be lower than the STAs can achieve alone, the District and DEP are developing and evaluating alternative treatment strategies for reducing P levels to meet a planning goal as low as 10 ppb for TP. Supplemental technologies, as they were originally described in the

Act, are envisioned to work with (or in place of) STAs to meet the final P target. However, the best combination of treatment technologies to meet the P concentration goal may include enhanced BMPs, as well as STAs and supplemental technologies. Phase II of the Everglades Program is focused on identifying, demonstrating and implementing water treatment technologies to achieve Act standards. The schedule for demonstration, full-scale design and construction of Phase II water treatment technologies, including the development of the Integrated Water Quality Plan, is shown in **Figure 8-1**.

EVERGLADES RESTORATION PHASE II SCHEDULE REQUIREMENTS AND GOALS*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Evaluate & Demonstrate Treatment Technologies											
Integrated Water Quality Plan Development											
Conceptual Design for Basin-Scale Treatment Facilities											
Detailed Design for Basin-Scale Treatment Facilities											
Construction of Basin-Scale Treatment Facilities											

* Note: These schedules are preliminary and contingent upon funding and other constraints (see Chapter 12)

Figure 8-1. Phase II schedule requirements and goals.

All supplemental technologies under consideration must meet guidelines established by the Act. All candidate treatment technologies must be demonstrated to be superior at achieving restoration goals, considering the following:

- load reduction,
- discharge concentration reductions,
- water quantity, distribution, and timing for the EPA,
- compliance with water quality standards,
- compatibility of treated water with the balance in natural populations of aquatic flora or fauna in the EPA,
- cost-effectiveness; and
- schedule for implementation.

Other evaluation criteria may include, but not be limited to, technical feasibility, possible adverse environmental impacts, and local acceptability of the effluent. All supplemental technologies must be applicable at the basin scale, i.e., they must be able to treat the runoff generated within the EAA basin during storm events.

The District has previously contracted with Brown and Caldwell Consultants to identify and rank supplemental technologies that might be applicable to reducing P levels in EAA runoff (Brown and Caldwell 1992, 1993a, 1993b, 1993c). As a follow-up to this study, the District contracted with PEER

Consultants P.C./Brown and Caldwell-Joint Venture to reassess the efficacy of existing nutrient removal technologies, investigate new and/or as yet unproven technologies, and consider using combinations of technologies in the design of an advanced treatment system capable of reducing TP to approximately 10 ppb (PEER Consultants, P.C./Brown and Caldwell, 1996). From an original list of 30 technologies, this desktop study identified the following as the most suitable for further investigation: stormwater treatment areas; managed wetlands; chemical treatment/direct filtration; chemical treatment/ dissolved air-flotation; chemical treatment/high-rate settling; submerged vegetation/limerock; and low- intensity chemical dosing of STAs. Preliminary cost estimates and benefits, defined as pounds of P removed, for some of the technologies were also developed. An additional concept, periphyton-based stormwater treatment areas (PSTAs), was determined at that time to have insufficient documentation to be included in this list.

Impacts of the Section 404 Permit

The United States Army Corps of Engineers (USACE) Section 404 permit for the construction and operation of the STAs, contains several permit conditions that have significantly influenced the level of effort and schedule for the supplemental technology program. If adverse impacts should be documented, special condition #1(b)6 requires the implementation of additional water quality measures for STA-2, by the end of the fourth year of operation after first discharge. The Act specifies first discharge as the date of the first flows across the degraded east L-6 Levee into Water Conservation Area (WCA) 2A, which could conceivably occur as early as 1999. This would potentially result in the requirement to implement additional water quality strategies (i.e. supplemental technologies) by 2003, three years earlier than the implementation date of December 31, 2006 specified by the Act.

Special condition #5 of the Section 404 permit requires the development of a strategy to achieve the final State water quality standard for P by January 1, 2001. However, DEP will likely not complete rulemaking to establish the final standard before the Act deadline of December 31, 2003. Based on the recent ruling regarding the permit challenge for the non-Everglades Construction Project (ECP) structures, a water quality strategy was defined as problem identification, solution identification and solution evaluation. This differs from the water quality plan, required by the Act in 2003, which is more comprehensive and will include solution development and implementation, conceptual design and a construction schedule to meet the December 31, 2006 deadline. Although the USACE Section 404 permit uses these terms differently for purposes of the permit, the District intends to provide the USACE with the most up to date information available to fulfill the Section 404 permit conditions that refer to strategies or plans.

Finally, special condition #7 of the Section 404 permit includes a list of nine potential supplemental treatment technologies to be investigated. The District originally proposed to investigate five of the most promising technologies (wetlands, managed wetlands, chemical addition/direct filtration, low intensity chemical dosing, and SAV/limerock) suggested by the Desktop Study. The addition of four more technologies (chemical addition/high-rate sedimentation, chemical addition/dissolved-air flotation, microfiltration, and periphyton-based STAs) has required a significant increase in funding (estimated at over \$3,300,000) and staffing for the program.

Most supplemental technology research and demonstration studies will be completed between 2000 and 2002. Although exceptional efforts are being made to meet the Section 404 Permit special

condition timeframes, compliance with those timeframes is likely not achievable. The District has requested modifications of the Section 404 permit that would rectify some the concerns identified above.

Integration of Research Findings on Supplemental Technologies with BMPs and STA Optimization to Achieve Final Water Quality Standards

The Act requires the development of a water quality plan by December 31, 2003 that will explain the District's approach on how to achieve and maintain the final P performance standard by December 31, 2006. This water quality plan will incorporate information on the best combination of STAs, BMPs, and supplemental technologies to meet the final P performance standard, as well as other State water quality standards if necessary. As the information is generated, District staff will be evaluating the performance results from BMPs and STAs, as well as the results of the research and demonstration projects for supplemental technologies and STA optimization. This information will be used to begin selection of the most promising combination of technologies to meet the yet-to-be-defined final P criterion. The methodology to determine the best combination of technologies will need to be developed. It will also need to consider the site-specific conditions that will potentially affect the successful implementation and performance of the combined treatment technologies. Other information that is required includes the final P criterion, establishment of the relationship between discharge levels and water quality in the EPA, the results of the C & SF Restudy and Lower East Coast Regional Water Supply planning efforts, and the incorporation of the Talisman property into the Everglades Restoration program (See **Chapter 12**).

Supplemental Technologies Under Investigation

In 1996 the District completed a comprehensive evaluation of promising water quality treatment technologies, ranging from constructed wetlands that require fairly low maintenance to full chemical treatment for the removal of P (PEER Consultants, P.C./Brown and Caldwell, 1996). Various combinations of the highest ranked technologies were evaluated on the basis of projected nutrient removal performance, costs, and compatibility with environmental criteria. This evaluation confirmed that STAs are indeed the best interim step towards achieving the long-term water quality and hydropattern restoration goals for the Everglades. In addition, other promising technologies were identified along with their major technological uncertainties. The most promising technologies are being investigated prior to the final decision on if, and how, supplemental technologies can be incorporated into the final Phase II solution. The District and DEP have initiated demonstration studies on these technologies to further determine critical design criteria such as performance efficacy, hydrologic operating characteristics, initial and annual costs, and identification of potential environmental impacts. Some of these have the potential of both on-farm treatment of hot spots and regional application. These technologies include the following:

- Chemical Treatment/Solid Separation (which includes Chemical Treatment/Direct Filtration, Chemical Treatment/High-Rate Sedimentation, Chemical Treatment/Dissolved-Air Floatation, Chemical Treatment/Microfiltration)

- Low-Intensity Chemical Dosing
- Managed Wetlands
- Submerged Aquatic Vegetation/Limerock
- Periphyton STAs (PSTAs)
- Wetlands (STAs).

Chemical Treatment/Solids Separation

Several chemical treatment/solids separation processes are currently being evaluated by the District's supplemental technology research program. These strategies are similar in that they use water treatment chemicals (i.e. iron or aluminum salts, usually with a chemical polymer to aid in coagulation) to precipitate P. Differences occur in the method of solids separation. The different methods of solids separation include: direct filtration, high-rate sedimentation, dissolved air flotation, and microfiltration and are discussed separately in the following text. The chemical treatment approaches described below are adaptations of technologies used in wastewater treatment or to produce drinking water. The primary research challenge for these technologies is to identify the optimum chemical application regime to remove P to desired levels, while minimizing the complexity of the treatment process. The issue of disposal of solids generated from these processes is also under investigation. Sludge disposal options may range from on-site land application to the requirement for transport and disposal in a landfill.

Direct Filtration - This system adds metal salts to the water to be treated and combines it in a rapid mixing chamber prior to filtration. Filters may consist of sand, coarse activated carbon, anthracite coal, garnet, alumina, or other granular material. Spent backwash from the filters is routed to settling ponds for further treatment. The supernatant from the settling ponds is returned to the head of the plant. Periodically, solids are removed from the settling ponds, dewatered, and disposed of appropriately (**Figure 8-2**). The technology appears capable of achieving 80 to 90% or more in P removal, however, these results are not based on Everglades-type water and thus may not necessarily be achieved in the Everglades system. The Wahnbach Reservoir plant in Germany (capacity 113 million gallons per day (mgd)) has been reducing P from 60-210 ppb to 5 ppb using an iron salt dose of 4 to 10 milligrams/liter (mg/L). Maximum filtering rates are 5 grams of solids per minute per square foot of filter area (gpm/sq ft). Preliminary tests on Everglades water indicate that due to its high organic matter content, a chemical dose two to three times greater than those applied elsewhere will be required (Metcalf & Eddy, 1998). This may result in an increase in solids production such that the Wahnbach filter design is overwhelmed. An additional research issue will be to identify a suitable filter media that will capture the required solids without requiring frequent filter cleaning.

High-Rate Sedimentation - Chemical treatment followed by high-rate sedimentation is a common method used in the United States to produce drinking water. This system removes chemically precipitated solids through high-rate sedimentation that can include inclined plate or tube settling and ballasted-floc systems that require less space than do conventional settlers. Inclined plate and tube settling increase the area available for settling in a horizontal flow system and thereby achieve more efficient settling. Microfine sand (100 to 150 micron diameter) adds weight to the floc particles and increases their settling velocity. Gravity filtration may be required as a final treatment step, although studies have shown that polishing is not always necessary if the sedimentation step is efficient. Solids are disposed of in the most beneficial manner. The technology appears capable of achieving 80 to 90% or more in P removal, although

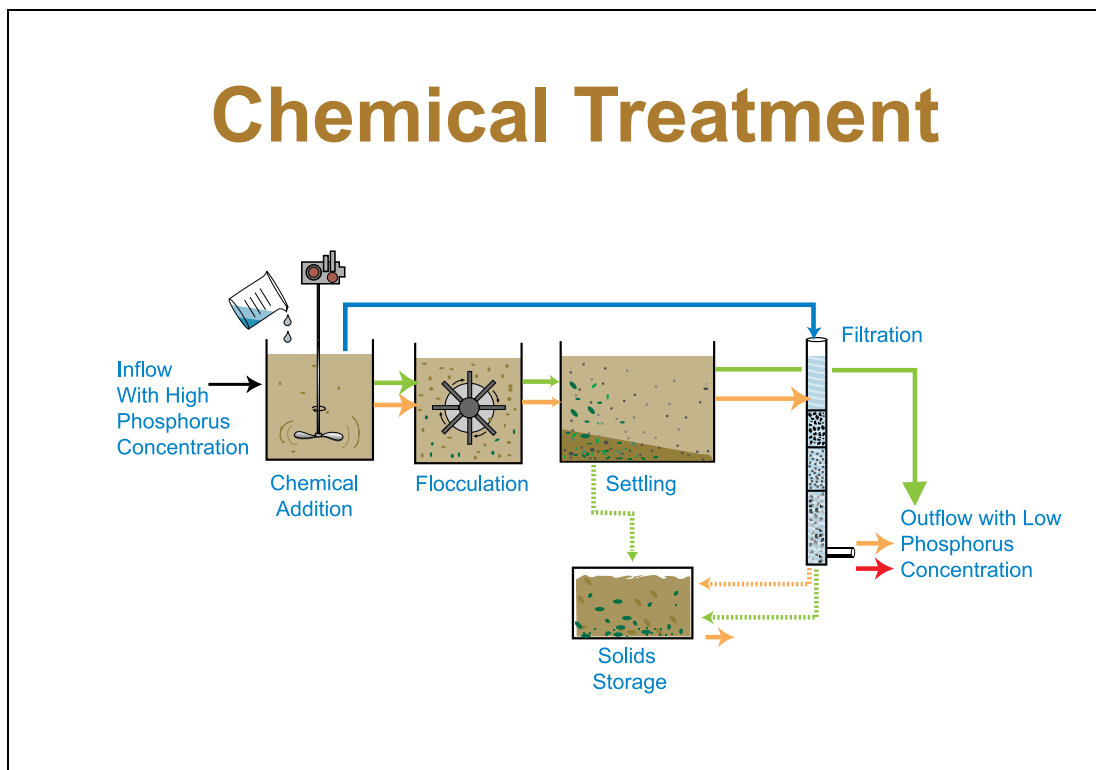


Figure 8-2. Chemical treatment.

these projections are not based on Everglades-type water and thus may not necessarily be achieved in the Everglades system. Cost savings can be realized if high-rate settling without a final filtration step is sufficient to meet water quality goals.

Dissolved-Air Floatation - This process removes precipitated solids by dissolved-air floatation. Floatation is achieved by dissolving air into a recycled, process effluent stream, under pressure. The recycled effluent stream then passes through a pressure-reducing valve and is blended with the flocculated influent. Dissolved air comes out of solution as tiny bubbles, which adhere to the floc particles and make them buoyant. The solids bubble to the surface, are skimmed off, and then disposed of appropriately. The underflow passes directly to a multi-media filter. This technology appears capable of achieving 80 to 90% or more in P removal. Again, these results are not based on an Everglades demonstration and thus may not necessarily be achieved in the Everglades system. Dissolved-air floatation in water treatment is common in Europe with plants operating at capacities up to 20 mgd. This process is also used in the United States in drinking water and wastewater applications. The efficiency of dissolved-air floatation will be compared to the other solids separation techniques on the basis of cost and performance.

Microfiltration - This process uses microfiltration to remove precipitated solids from water. The chemically dosed water and precipitated particles flow through a pressure vessel containing tubular fine-pore membranes, with a pore size of 0.1 to 0.01 micron. In contrast, reverse osmosis uses a pore size less than 0.001 microns. The water passes from one side of the membrane to the other, which can be operated in either a positive or negative pressure mode. Solids cannot pass through the membranes and are trapped on

the entrance side. Trapped solids are flushed from the membranes and sent to a settling pond for further treatment and disposal. Solids are removed from the pond and disposed of in an appropriate manner. Pond supernatant is returned to the head of the plant. The membrane is cleaned with chemicals such as citric acid. A system of with a 20-mgd capacity will soon be constructed in France.

Current Status of Chemical Treatment Projects

The District selected a contractor to construct a pilot-scale facility for the demonstration of chemical treatment followed by direct filtration, high-rate sedimentation, dissolved-air floatation, and microfiltration solids separation. Phases 1 and 2 of this project, which included bench-scale or jar testing of EAA waters to estimate the amount of chemicals necessary to remove P in the highly organic waters, have been completed. A portion of this work was funded through the United States Environmental Protection Agency (USEPA) Section 319(h) grants funding program, administered by the DEP. Results of Phase 1 and 2 for the chemical treatment/solids separations project and microfiltration project are presented below. Phase 3 will commence in early 1999.

Phase 1 tests included bench-scale evaluations of the comparative P removal capabilities of aluminum and iron salts for EAA water. Chemicals which demonstrated promise during Phase 1 tests were further evaluated in Phase 2 tests to isolate some of the conditions which seem most significant to performance of the chemical. Phase 2 tests examined how P removal capabilities were affected by initial P concentration, chemical dosage, use of polymers, use of adsorbents, initial pH, and adjusted pH. The P removal potential of several iron salts was tested with low-, medium-, and high-P waters (defined respectively as less than 30 ppb TP, 30 to 100 ppb TP, and greater than 100 ppb TP). Ferric sulfate, ferric chloride, polyferric sulfate and ferric sulfate with a polymer blend were evaluated. All chemicals were received in concentrated liquid solution (10 to 12 percent) from the manufacturers. Jar tests were also conducted to evaluate the feasibility of absorbing P with activated alumina, iron oxide (magnetite), and hematite. Results for both settling and filtration were obtained. Filtration experiments were conducted using Whatman 40 filters and, to a lesser degree, small sand filter columns. The following primary conclusions were reached.

- TP levels of 10 ppb or lower can be achieved from a range of influent P concentrations (12 - 430 ppb) by chemical precipitation and filtration.
- P reduction achieved for each mg/L metal salt added was higher for high-P waters (> 50 ppb) than for low-P waters.
- With high metal salt dosages (> 20 mg/L Al or > 40 mg/L Fe), filtration and settling resulted in approximately the same P concentrations.
- Orthophosphate was easier to remove than the polyphosphate and organic P components of the influent water.
- Adsorption tests indicated that adsorbents only removed orthophosphate. High dosages of metal salts are necessary to remove the remaining organic phosphate and polyphosphate components.
- Adjusting the pH between 6 and 9 did not result in a significant difference in P removal. When pH was adjusted above 9 (using 150 mg/L or higher lime dosage), P removal increased significantly.

- No significant differences in TP removal were noted when lime was introduced after rather than before the metal salt (ferric sulfate).

One recommendation for further study (in Phase 3) included varying the mixing intensity and time at the pilot plant to evaluate whether longer flocculation can result in increased P removal at a lower coagulant dosage. Another recommendation for further study included testing the P removal capability of iron and aluminum salts at low dosages with lime addition.

The field work for microfiltration, which will form the basis for additional work under the chemical treatment project, was conducted under contract to the DEP at two locations in the Everglades Nutrient Removal (ENR) Project, from September 1996 to September 1997. A final report was submitted in May 1998 (Conestoga-Rovers and Associates, 1998). Based on the results of the one-year demonstration project, some of the conclusions are:

- Chemical treatment (Al or Fe) followed by microfiltration is capable of removing TP down to 10 ppb (P) for both post BMP and STA waters. Chemical dosages required for post BMP and STA waters range from 8 to 10 and 3 to 4 mg/l as Fe or Al, respectively.
- Even though ferric chloride and alum P removal rates were approximately the same, ferric salts would be preferred for use in full scale applications due to their apparent ability to extend microfiltration run times and also because of recent environmental perceptions related to the use of aluminum.
- Since the post BMP microfiltration scenario requires an up-front equalization basin approximating the size of an STA, it is unlikely that full-scale application of microfiltration to treating BMP water to effluent TP level of 10 ppb would be cost effective.
- Bioassay and algal growth potential studies conducted on feed and filter samples demonstrated no sustained adverse impact on receiving surface waters.
- Membrane technology (microfiltration or ultrafiltration) has potential to be an integral part of a coupled STA-low chemical-dosing membrane system particularly when considering higher Phase 2 (i.e. 20-30 ppb) effluent TP targets and potential water supply considerations.

Operation of the pilot treatment facility (Phase 3), which includes the evaluation of the different solids separation techniques, will begin in 1999. This work will be conducted for a period of several months at the Supplemental Technology research site located adjacent to the ENR Project outflow pump station (post-STA research site). Further testing at the Supplemental Technology research site located near the ENR Project inflow canal (post-BMP research site) may not be necessary, as the results of the Phase 1 and 2 jar tests, and the microfiltration demonstration project indicate that information on chemical dosing and solids production obtained at low P inflow concentrations will be applicable to high phosphorous inflow concentrations. In addition, operation of a chemical treatment facility upstream of an STA will require the construction of an equalizing basin of approximately the same size as an STA to treat all inflows, which would result in extremely high construction costs.

Low-Intensity Chemical Dosing

Small doses of iron salts are added directly to the constructed wetland (STA) influent to precipitate soluble P and help coagulate the chemically precipitated P and naturally occurring particulate P. No rapid

mixing, flocculation, or settling basins are used. Methods of distributing the treatment chemicals effectively must be developed. The constructed wetlands act as settling basins and capture precipitated solids. Chemical precipitation provides an additional mechanism for P removal, may improve particulate P removal capability, and may enhance the P retention capability of the sediments. This concept has been used in Belgium, along the Rhine River, and in Minnesota on lake water, although it has not been used with constructed treatment wetlands here in Florida. The wetland provides both P uptake as well as filtration of the precipitate (**Figure 8-3**). Due to the biological component of the system, a minimum of one full year of field testing will be required to obtain reliable performance and design information. Issues of concern with this technology are: (1) the stability of the sludge blanket as it accumulates on the floor of the STA in response to high flow rates and changing aerobic/anaerobic conditions; (2) effects on the long-term performance of the STA due to enhanced sediment accumulation; (3) required chemical application rates; and (4) how to effectively distribute the added chemicals.

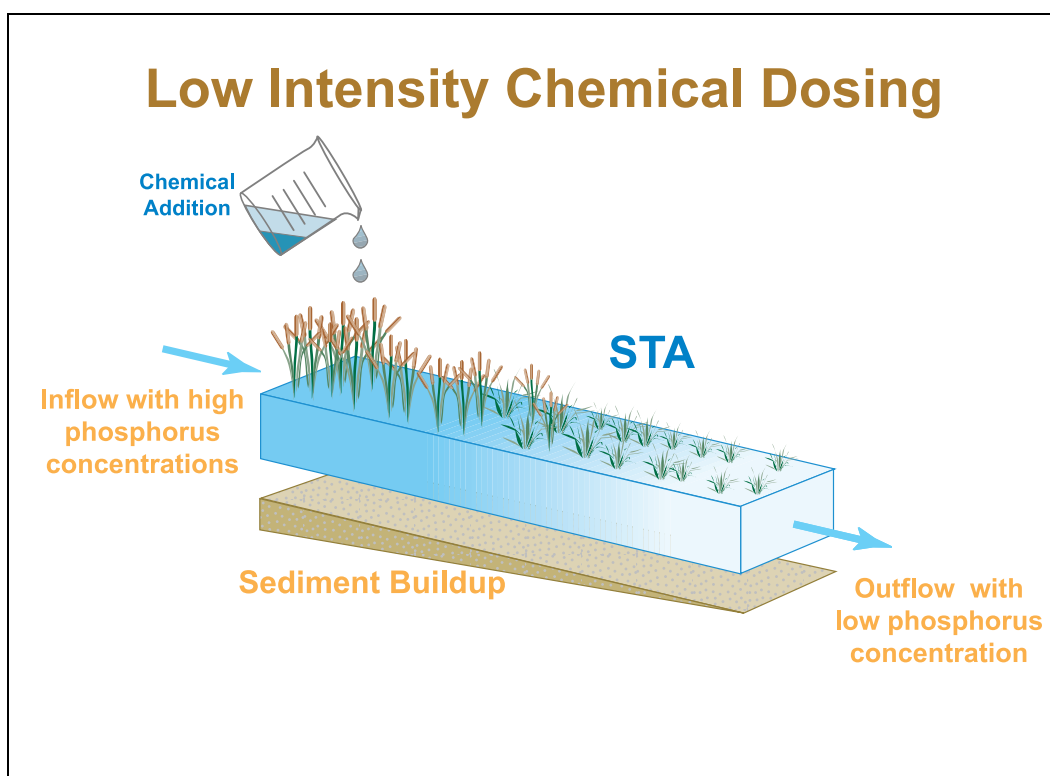


Figure 8-3. Low-intensity chemical dosing.

Current Status of Low-Intensity Chemical Dosing

The low-intensity chemical dosing project is being conducted by Duke University researchers under contract to the Everglades Protection District and DEP. USEPA Sec. 319(h) funding, administered by DEP, has been received for this project. Work is underway in the ENR Project. Pilot-scale demonstration studies for low-intensity chemical dosing began in the spring of 1997. Microcosm scale tests are continuing and mesocosms are installed at Site 1 in the ENR Project. Background data is also being collected at Site 1. The District will be conducting the next phase of the project. Experiments for the next phase will include optimization of chemical dosing and the design and construction of flow-ways, or

flumes, for determining the effects of water velocity on the stability of the chemical sludge blanket deposited within the ENR and P removal performance.

Managed Wetlands

With managed wetland technology, stormwater is mixed with chemicals to initiate flocculation. Potential treatment chemicals include iron and aluminum salts, and a chemical polymer as a coagulant aid. Flocculation and solids separation occur as described in high-rate sedimentation or in a settling pond. The chemical treatment step occurs upstream of a constructed wetland to provide a mechanism for controlling the TP load to the wetland and to increase the performance and reliability of the overall treatment system (**Figure 8-4**). By adding the chemical treatment step ahead of the wetlands, the majority of P is removed prior to the introduction of flow into the wetlands, thus potentially reducing wetland area requirements and chemical application rates. P removal to less than 50 ppb has been documented. Again, due to the biological component of the system, a minimum of one full year of field testing in a wetland system will be required to obtain reliable performance and design information. Issues of concern with this technology are related to scale-up in size and the ability to handle large stormwater flow events.

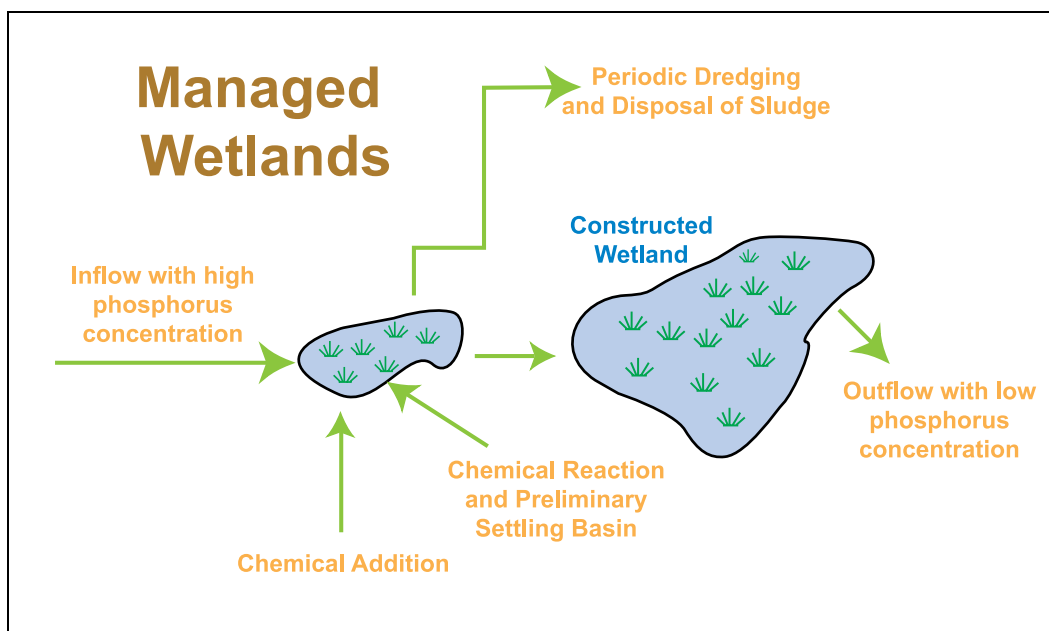


Figure 8-4. Managed wetlands.

Current Status of Managed Wetlands

This project will be conducted jointly with the Seminole Tribe of Florida and the District to investigate the managed wetlands technology. A portion of the project will be conducted in the ENR Project test cells to determine the efficacy of this technology in cattail systems, which is the plant community most likely to become established in a constructed wetland. The second phase of the project will look at the performance of this technology when coupled to a forested wetland or cypress-dominated system, which is the habitat type found primarily on Tribal property. USEPA Section 319(h) funding has

been received for the initial phase of this project, with additional funding anticipated for later phases. This project will begin in the fall of 1998.

Submerged Aquatic Vegetation (SAV)/Limerock

This treatment method capitalizes on the removal of P through natural pH-moderated precipitation and adsorption mechanisms. In this system, P-laden runoff is fed to a submerged macrophyte-dominated wetland. Photosynthesis by macrophytes and periphyton raises the water's pH. The elevated-pH water is discharged into a crushed limerock bed where P will adsorb onto the limestone surface and be removed from the water stream (**Figure 8-5**). The limerock bed will need to be replaced or refurbished on some periodic basis. Treatment performance fluctuates diurnally with the best performance occurring during daylight hours. Information on this treatment technology is relatively limited and will require testing at several scales. In addition, at least two years of field testing of this developing technology will be required to obtain reliable design and performance information.

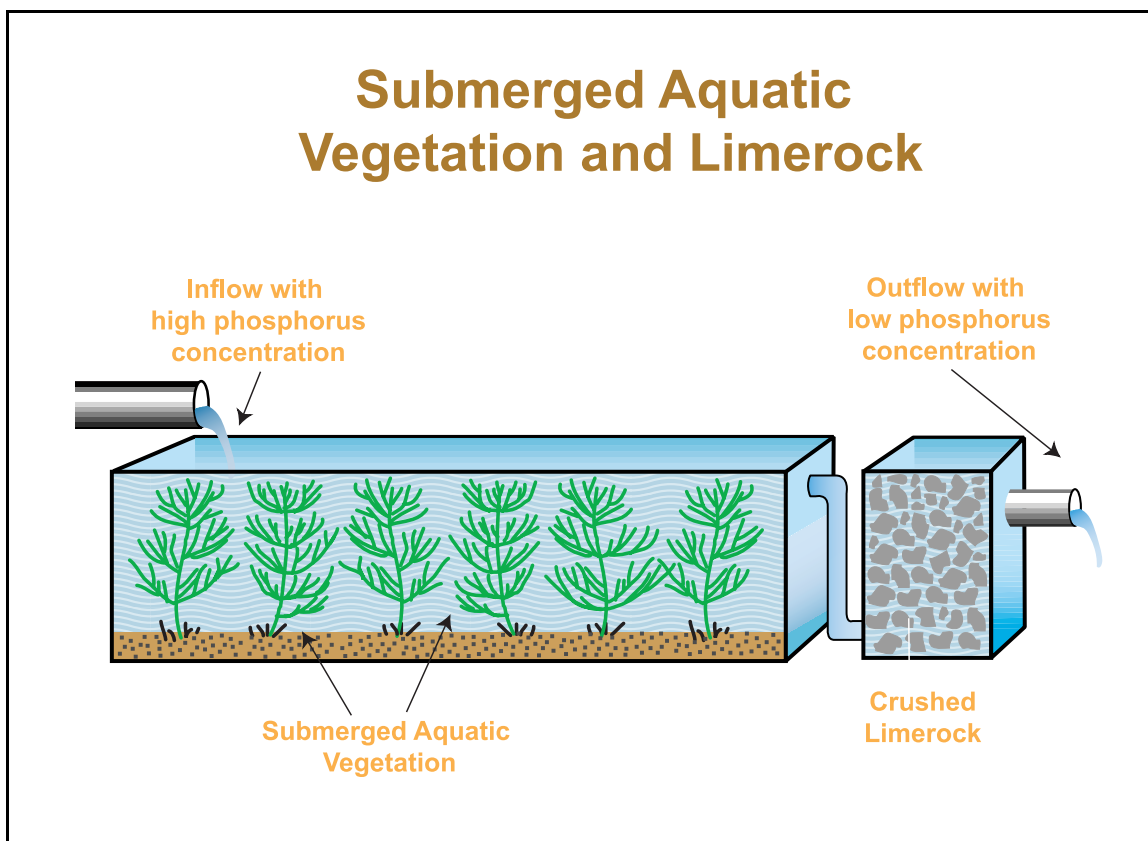


Figure 8-5. Submerged aquatic vegetation and limerock.

Current Status of SAV/Limerock

This project is co-located with the Chemical Treatment/Solids Separation and PSTA projects at the north and south Supplemental Technology research areas at the ENR Project. A contractor has been selected by the District and work was initiated in February 1998. The fabrication and set-up of the

experimental tanks, limerock reactors, and associated water delivery systems was completed by April 1998. All tanks were then stocked with submerged aquatic vegetation and flow-through operations started. The vegetative community in the tanks was given time to become established before initiating the various experiments that are part of the study. Data collection began in June 1998. Variables that may influence the P removal performance of the SAV/Limerock system include hydraulic retention time, water depth, limerock chemical composition and size, and harvesting of the SAV. All of these variables will be investigated over the course of the study. USEPA Section 319(h) funding, administered by DEP, has been received for this project. If results from the ongoing study are promising, in mid- to late-1999 a larger, second study will be conducted in the ENR Project test cells. This study should yield design-level information by the year 2001.

Periphyton-based STAs (PSTAs)

This treatment concept uses the natural ability of periphyton (attached algae) to remove P from the water column to very low levels. The conceptual design consists of removing the soil/substrate down to the underlying limestone to create an environment that will support periphyton growth while preventing the establishment of rooted macrophytes. P removal is achieved through periphyton uptake and precipitation with calcium carbonate during the growth process. The concept, as proposed, is relatively passive so that short-term operation and maintenance costs are expected to be lower. After dry periods, periphyton communities typically reestablish within 24 hours of a rain event. Optimum water depth for the system is estimated between 0 and 2 feet (**Figure 8-6**). Issues associated with this concept include the long-term performance and stability of an algal-based system, the level of required maintenance, and level of macrophyte control that may be necessary to prevent shading of the periphyton community. At least two years of field-testing will be required to obtain information on the feasibility and function of this concept for scale-up design and operation.

Current Status of PSTA Studies

Initial field investigations on the construction and hydrologic feasibility of periphyton STAs (PSTAs) in the EAA were completed in November 1997. These tests confirmed that the high groundwater elevations in the project area will need to be addressed in the design and operation of the field-scale test cells. In addition, the amount of seepage into or out of the test cells will need to be quantified in order to determine the influence of groundwater/surface water interactions on the water and P mass balance budgets. A contractor was selected in April 1998 to conduct the necessary biological and engineering research on the concept. Mesocosm-scale and field-scale studies will begin in December 1998 to demonstrate the feasibility of PSTAs to reduce P concentrations to very low levels. Research will be conducted at the supplemental technology research sites within the ENR Project and within the footprint of STA-3/4. Variables that may affect the P removal performance of a PSTA include water depth, substrate type, hydraulic loading rate, the presence or absence of macrophytes, and periodic dryout of the system. All of these variables will be examined over the course of the study. The project is divided into two phases, each of 18 months duration. Depending on the results of the first phase, which will focus on key engineering and biological questions, the District may elect to stop the project at that time. In addition, the USACE will be conducting PSTA research in the areas of STA-1 East and the C-111 project area. The District and USACE are continuing to coordinate closely between these projects to ensure the highest quality research for the least total cost.

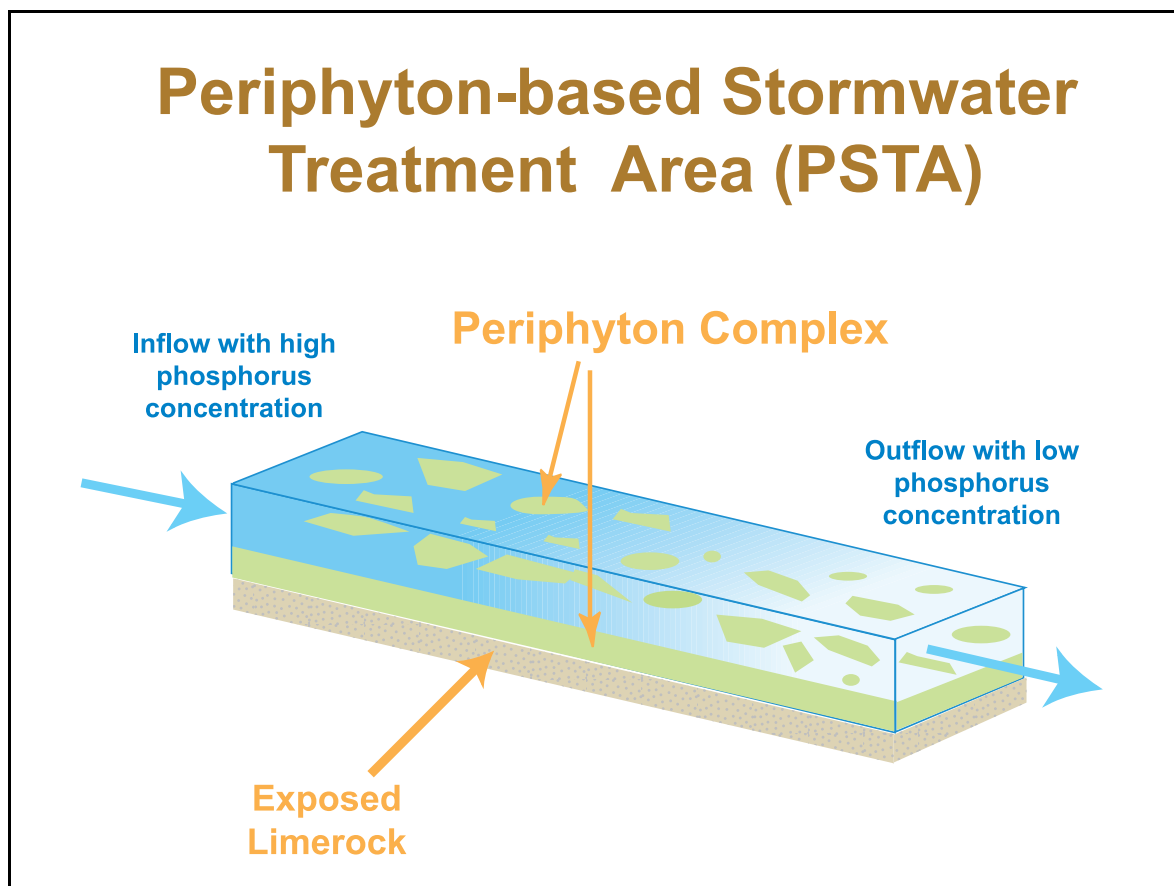


Figure 8-6. Periphyton-based Stormwater Treatment Area (PSTA)

Wetlands

Constructed wetland treatment systems, such as stormwater treatment areas (STAs), remove P by exposing it to a suite of naturally occurring biological, chemical, and physical processes. Uptake by macrophytes, subsequent plant die-off, the actions of organisms that feed on plant debris, and the slow flow of water within the STA interact to accumulate material on the bottom as peat. Ultimately, the P is stored in the peat and muck soils. Flow passing through the STA is collected in an effluent canal and pumped out of the system directly into a WCA or receiving canal. Issues related to STAs are the integration of the existing Everglades Construction Project with other treatment technologies, and how to enhance STA performance through operational changes.

Current Status

A combination of field research, evaluation of other available system data, and application of a “Wetlands Water Quality Model” is being used to identify ways to optimize the nutrient-removal performance of constructed wetlands. Research has been under way in the large treatment cells of the ENR Project since 1994. In addition, activities are planned in the smaller ENR Project test cells where greater control of hydraulic loading rates and water depth, and statistical replication is available. The anticipated

results will include recommendations for enhancing STA operations with respect to water retention time and water depths. These are targeted to be completed no later than December 31, 2001. Also, as STAs come on-line, their operations will be continuously monitored and evaluated, and valuable feedback will be incorporated into other STA operations. Please refer to Chapter 6 for more details on STA Optimization.

Evaluation and Comparison of Supplemental Technologies

To properly evaluate the results of diverse supplemental technology demonstration projects, it is necessary that the data obtained from all such demonstration projects be collected in a manner that allows scientifically valid comparisons to be made. To ensure that comparable information is obtained from each supplemental technology study, the District entered into a contract to develop a supplemental technology standard of comparison that will be applied to each project. This standard is intended to be applied evenly to all technologies to provide a reasonable analysis of the potential of each technology with minimal bias. The standard of comparison provides direction to each supplemental technology project on the data to be collected as well as the information necessary to begin the design of full-scale applications. The standard of comparison also provides for the development of a data base for the supplemental technology projects and the design of an evaluation method to assess the performance of each technology.

The development of all phases of the standard of comparison is a joint process that includes the District, DEP, and the Everglades Technical Advisory Committee (ETAC). The data collection guidance document was completed in December 1997 and distributed to all of the supplemental technology demonstration projects. The guidance document directs the collection of comparable experimental data and includes the following: identification of flow streams to be sampled; flow measurements and methodologies; analytical parameters, methods and sampling frequencies; QA/QC requirements; data formats; identification of liquid and solid-side streams to be sampled; analytical procedures for evaluating compatibility with downstream environments; the data set to be utilized for modeling long-term performance; and development of the conceptual design and preliminary cost templates for the full scale facility. The contract guidance document can be found in **Appendix 8-1**.

Application of the Standard of Comparison

The second phase of the standard of comparison development has two objectives: 1) the development of an evaluation methodology, and 2) development of a comprehensive database. The evaluation methodology proposes five primary and five ancillary concepts, analyzed through a combination of quantitative and qualitative methods, that will be used to compare the diverse supplemental technologies. Primary concepts include the level of P concentration reduction achieved, the level of P load reduction achieved, cost-effectiveness, evaluation of potential toxicity of the technology and implementation schedule. Ancillary concepts include the feasibility and functionality of scaled-up design and cost estimates, operational flexibility, sensitivity of technology to fire, flood, drought and hurricane, level of effort to manage side streams generated by the treatment process (may include potential benefits to be derived from the side streams), and other water quality issues. A database will be developed where supplemental technology project data will be compiled for evaluation.

The evaluation methodology will also include initial cost estimates and benefits (calculated as the pounds of P removed by the technology) that will be used to as part of an evaluation of costs and benefits of each technology. The process by which the standard of comparison evaluation methods will be applied is under development and will be completed in 1999. At this time it is envisioned that a scoring system will be developed for the primary concepts, and the ancillary concepts will be evaluated qualitatively. The quantitative data will be entered into the standard of comparison data base and the qualitative information will be provided by the research teams as written summaries. When the first demonstration projects have produced standard of comparison data sets, possibly as soon as late 1999, the information will be compiled and evaluated. The process will be repeated as each supplemental technology project is completed and data are added to the database. It is anticipated that the evaluation methodology developed for the supplemental technology standard of comparison will be applicable, either in its entirety or in part, to the selection of the optimal combination of BMPs, STAs and supplemental technologies. The complete database of all of the supplemental technology projects should be available toward the end of 2001.

Scheduling and STA-3/4 Design

The District is continuing to focus efforts on conducting the necessary research of the most promising supplemental technologies identified in the Desktop Study (Peer Consultants, P.C./Brown and Caldwell, 1996) and the USACE Section 404 permit for the STAs. The majority of this information is required by the end of the year 2000, in order to meet the USACE Section 404 permit deadlines. Based on the current schedules and timelines of all the supplemental technology projects (**Figure 8-7**), it is unlikely that the USACE Section 404 permit deadlines will be met.

Final design of STA-3/4 is scheduled for 1999 through 2000. Unfortunately, information from the supplemental technology demonstration studies that could influence the design of this STA will be largely unavailable. However, efforts are currently under way to consider refinements to the design of STA-3/4 that would allow the flexibility to incorporate supplemental technologies as design details are developed. This would be contingent upon the demonstrated need for Phase II supplemental technologies, as well as funding availability. STA-3/4 design will incorporate information from the Lower East Coast Planning efforts, and the comprehensive Central & South Florida Restudy project, as applicable.

Develop Integrated Water Quality Plan (BMPs, STAs, Supplemental Technologies)

The Act requires the development of an integrated water quality plan by December 31, 2003. This plan must consider the performance results from BMPs and STAs, as well as the results of the research and demonstration projects for supplemental technologies and STA optimization, in recommending the most promising combination of technologies to meet the final phosphorus standard. Prior to this date, the USACE Section 404 permit requires the development of a water quality strategy by January 1, 2001. The water quality strategy will be realistically limited to an evaluation of the supplemental technology, BMP, and STA Optimization research data available by the fall of the year 2000. Additional efforts will be needed to integrate all of the data produced by these research programs, including the phosphorus threshold research, to meet the EFA deadline for the integrated water quality plan by 2003. Costs and

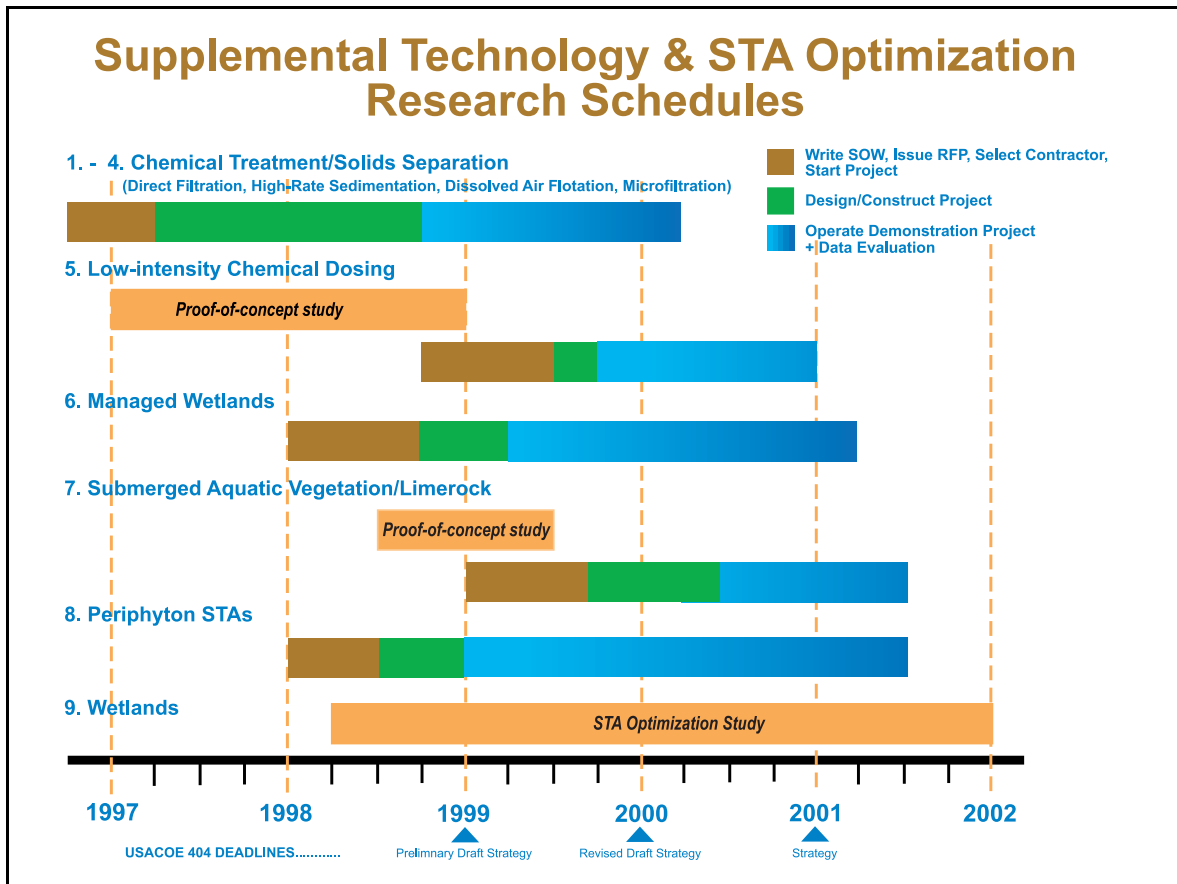


Figure 8-7. Supplemental technology and STA optimization research schedules

benefits of each technology will also need to be determined. All of the supporting information and the final evaluation method will need to be incorporated into the water quality plan required by the Act.

The timelines associated with the information required for the development of the integrated water quality plan are complex. The majority of the research for the supplemental technology demonstration projects will be completed by mid-2001. Actual phosphorus threshold values (and other water quality parameters) may not be established until December 31, 2003. The results of the Restudy and other planning efforts need to be integrated into the plan. In addition, the relationship between discharge levels and water quality in the EPA needs to be determined. All of these issues need to be satisfactorily addressed before the integrated water quality plan can be completed. See **Chapter 12** for more information on the issues associated with the Integrated Water Quality Plan.

Selection and Implementation of Phase II Technologies

The Florida Legislature directs that the ECP and regulatory requirements associated with the Statement of Principles of July 1993 be pursued expeditiously, but with flexibility, so that supplemental technologies may be utilized when available. By December 31, 2006, the FDEP and the District shall have taken such action as may be necessary so that water delivered to the EPA meets or exceeds state water quality standards, including the phosphorus criterion. Phase II implementation activities will integrate the results of ongoing research, planning, and regulatory activities.

Phase II implementation (the design and construction of Phase II technologies) will of necessity overlap the development of the integrated water quality plan (**Figure 8-1**). Conceptual design for the basin scale treatment facilities needs to commence in 1999. Construction must commence no later than 2004. Although the evaluation criteria for supplemental technologies will identify the most promising technologies, additional site-specific feasibility studies will likely be necessary. The ultimate combination of approaches will need to consider the site-specific conditions that will potentially affect the successful implementation and performance of the combined treatment technologies. Pilot projects of some of the more expensive technologies may also be desirable. Other issues for Phase II implementation include land requirements and land acquisition; funding for the Phase 2 implementation has not been designated.

Research, Development and Implementation Costs

The projected District *ad valorem* expenditures for verification and demonstration of each supplemental technology are shown in **Table 8-1**. The total dollar amount is approximately \$10.04 million. This estimate does not include funding from other sources (i.e. USEPA Sec. 319(h) funds).

Table 8-1. Preliminary cost estimates for research associated with supplemental technologies

	Post-404 Cost Estimates *					Total
	1997	1998	1999	2000	2001	
Managed wetlands	\$0	\$408,635	\$600,000	\$400,000	\$0	\$1,408,635
Low-intensity chemical dosing	\$0	\$0	\$246,382	\$443,487	\$637,162	\$1,327,031
SAV/limerock	\$415,000	\$293,675	\$617,235	\$511,082	\$252,808	\$2,089,800
Chemical treatment/solids separation	\$1,170,000	\$667,765	\$53,561	\$0	\$0	\$1,891,326
Microfiltration	\$457,350	\$25,000	\$26,781	\$0	\$0	\$509,131
Periphyton STAs	\$0	\$885,000	\$1,000,000	\$928,692	\$0	\$2,813,692
Total						\$10,039,615

a. All projects will be phased, with stop/go points. Actual expenditures may be different than indicated as information is gained and the approach fine-tuned.

Initial cost estimates for some of the Phase II technologies under investigation were provided by the Desktop Evaluation conducted by PEER Consultants P.C./Brown and Caldwell in 1996. However, these cost were extremely preliminary and were not based on data derived from tests with EAA waters. The initial estimates were also based on a number of assumptions that have since proved to be incorrect. Technologies that rely on chemical addition with some form of solids removal are proving to be very expensive. These costs may actually be upwards of 150 percent higher than initial estimates. Microfiltration has been shown to be very expensive. Although no initial cost estimates for microfiltration were calculated in the 1996 Desktop Evaluation (PEER Consultants P.C./Brown and Caldwell), the 1998 final report for the microfiltration study included estimated costs for construction and operation. The fifty-year costs for microfiltration for a single basin (STA-2) ranged from \$497 to \$553 million for post-BMP application to \$258 to \$307 million for post-STA application. These cost estimates include two critical assumptions; a 10% bypass was assumed for both applications at peak flow, and flow equalization was to be provided by the STA in the post-STA application. Flow equalization is provided through two additional feet of water storage above STA design criteria, which violates the design criteria. Therefore, a flow equalization basin would also be required in the post-STA application.

Systems that rely on passive biological processes are anticipated to have lower capital operation and maintenance costs than highly engineered systems, but this is yet to be proven. In addition, biological treatment processes usually have much greater land requirements. Through the continuation and completion of the supplemental technology research projects described above, the District will obtain substantially more information by December 31, 2001 on the costs and benefits associated with each technology. This information will be provided to the Legislature in the peer-reviewed report required by the Act by January 1, 2002.

The level of funding needed for Phase II implementation is unclear at this time. The funding source for Phase II implementation has not been designated. The District has been utilizing *ad valorem* taxes at the present time and is accounting for it separately should reimbursement be forthcoming. Funding requirements will be contingent on the optimal combination of enhanced BMPs, STAs, and supplemental technologies determined to achieve the long-term water quality and hydropattern goals of the Everglades restoration. Cost estimates, as well as the appropriate mixture of private, state and federal funds, will be developed concurrently with the research and demonstration studies (described above) scheduled for completion between 2000 and 2002.

Findings on Supplemental Technologies

- Nine technologies have been identified as having potential applicability to the Everglades Construction Project and are currently under investigation.
- Although research was initiated in 1997, information on the most promising technologies will not be available for the design of STA-3/4.
- Earlier cost estimates appear to be too low for two technologies (microfiltration and chemical treatment). Revised information on costs for Phase II technologies will be available from Phase II demonstration projects.

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